Modifying the Abrams Tank For Fighting in Urban Areas

by Sergeant First Class Ira L. Partridge

The regimental commander was discussing the problems tanks might encounter in urban situations: "If we found ourselves in action in Bosnia, or in a new Somalia or Chechen-like scenario, how fast could we deploy a few M1 tanks that were specially modified for MOUT? A few of the right vehicles could make a big difference...."

He then suggested some features that would not cost much to add to the M1-series:

- A precision mounted .50 caliber capable of taking out a sniper at long range
- Grenade launchers that fire high explosive rounds
- Fiber-optic cameras to provide a buttoned-up crew a full range of view
- An automatic 7.62mm gun turret for the TC or loader's hatch, capable of being aimed and fired from under armor
- Additional spaced armor on the turret roof
- A new canister round in the basic load

"These improvements could be accomplished fast in an emergency deployment," he said. "If we work on the prototype now, and put some ideas to work, we can make this a real option if it is needed."

Armor leaders have long acknowledged that the Abrams main battle tank (MBT) may have to fight in an urban environment, a mission commonly referred to as Military Operations in Urban Terrain (MOUT). But it took until May of 2000 for the Army to open the first MOUT city specifically designed to train mounted warriors with Abrams tanks, along with the other members of the combined arms team.

Two Ways to Approach MOUT Tactics

A combined arms team should always be the primary maneuver force in MOUT environments. The tank's inherent features — a large caliber precision cannon, several machine guns mounted in stable cradles carrying more ammunition than two squads of infantry, and a moveable protective barrier — would be an undeniable asset to this combined arms team.

Fighting in MOUT is slow and deliberate, regardless of the care given to protecting the force or civilian population. MOUT fighting also presents many tactical problems. The Israeli Defense Force (IDF) and the Russian Army are forces that have both recently conducted combat in MOUT environments, with each using fundamentally different tactics.

At one end of the spectrum are the tactics used by the Russians in Chechnya. During combat operations between 1994 and 1996, the Russians suffered devastating losses in city fighting due to badly defined strategy, poor tactical maneuver, and inadequately protected vehicles. Their tactical solution, however, came at a price that would appall most Western powers. Russian forces, towards the end of the first Chechen war, adopted a scorched earth policy similar to tactics used during World War II. Air power and artillery were liberally used to reduce urban environments to rubble before maneuver forces would enter to mop things up.

The Russian weapon of choice for urban warfare in Chechnya seems to be the TOS-1 heavy flamethrower system, designed to defeat targets with the effects of high temperature and extreme pressure by firing 30 incendiary rockets singularly or in salvo.[1] TOS-1s and massed artillery became a way for the Russians to achieve a "bloodless" victory — for them. This combination of TOS-1s and artillery is capable of releasing large clouds of flammable gas and creating massive blasts that incinerate buildings and people.[2] In the second Chechen war, Russian tactics have been similar. The following excerpt describes the outcome:

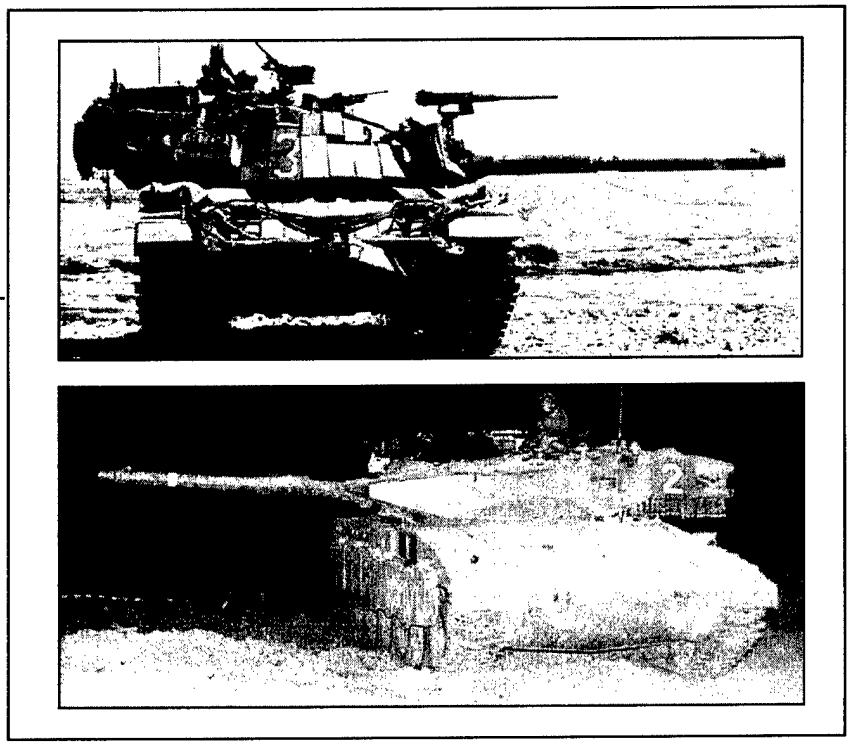
> "Today, Grozny is no more. The contrast between the damaged Grozny before the latest battle and the utter destruction afterwards could not be more pronounced. The literal leveling of the city points to lessons that the Russian Armed Forces learned from their earlier battles for Grozny."[3]

By removing the urban from urban-environment, Russian forces reduced the tactical problem presented and created a more favorable battlefield.

Israeli forces, on the other hand, demonstrated in the 1982 Lebanon campaign that MOUT operations are able to achieve tactical success without indiscriminate destruction or civilian casualties. They learned that, in MOUT, infantry must advance dismounted as part of a combined arms team, and operational timetables cannot be set to keep pace with mounted maneuver forces.[4] By surrounding and isolating large urban areas, the IDF took a slow, deliberate, and systematic approach to successfully clear cities. Dividing and subdividing the MOUT into areas that were subsequently reduced using direct and indirect coordinated fires spared unnecessary collateral damage to property and the civilian population. If faced with a similar tactical fight in MOUT, the U.S. Army would likely use similar tactics.

But tactics and training are not the only areas the Army will have to master to succeed in MOUT as part of the combined arms team. Systems and components — preferably "off the shelf"— will be needed to improve the fightability and survivability of the Abrams tank in a MOUT environment.

The most effective combat technique in MOUT fighting is for tanks and infantry to work together as part of a combined arms team. MOUT is not just an infantry problem, and effective use of armor in MOUT quickly becomes an issue when bullets are flying. According to published doctrine, armored vehicles will face a variety of tactical problems and possibilities in MOUT environments.[5] Issues like restricted



At right, two Israeli installations of the .50 caliber M2HB machine gun on the gun mantlets of, top, an M60, and below, a Merkava. Originally a training device, this modification allows precision single-shot fire at snipers and lightly armored targets.

movement, complicated and confused command and control, and the canalizing effects presented by buildings will be unlike maneuvering in open terrain. Additionally, the Abrams tank has limitations imposed by its design — the first being its sheer size. Most tankers know first-hand the challenges of trying to negotiate a street or town with a behemoth 70 times larger than the typical vehicle. In addition, the main gun's limits of elevation and depression — and the traversing restrictions imposed by narrow streets — will hamper its effectiveness against targets in tall buildings and basements. A third problem is the dead space in the area immediately surrounding the tank. This dead space falls between the sides and rear of the tank and the closest point that can be seen through the vision blocks. Another problem in the MOUT environment is the tank's exposure to attack from above, which is an area that is not as heavily armored as the tank's frontal armor.

Each of these problems can be overcome by technological solutions currently available that would make the Abrams better suited to fighting in a MOUT environment. What follows are ways that the Abrams could be improved to better protect the crew and enhance its lethality in MOUT.

Precision .50-Caliber Machine Gun

In order to achieve the precision necessary to kill a point target at an extended range using a .50-caliber machine gun, the weapon must be mounted to take advantage of the tank's fire control system. This can be accomplished in two ways. You can mount the weapon as a coax or attach it to the gun mantle using a Telfare[6] device with an M2 .50-caliber machine gun set for single shot.

Mounting the weapon as a coax may sound like a good idea at first, but the concept was studied and rejected when the Abrams was first being developed in the '70s. There were two primary reasons for rejecting the concept. First was the volume of brass produced when the weapon fired: how do you remove the brass from the turret? Second was the weight differential at the back of the cannon. Not that the added weight of the machine gun and a defined volume of ammunition could not be balanced. But the issue of a several hundred pound difference in weight that occurred before and after firing the ammunition, creating a transitory situation of going from back-of-the-gun-heavy to back-of-the-gun-light, was a difference in balance that could not be adequately resolved.

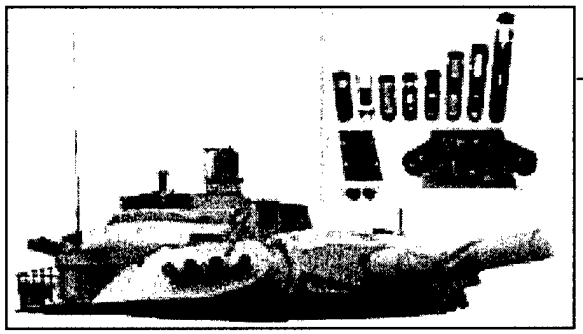
A better idea is to use a single shot .50 caliber mounted on a Telfare device. The device is already in the inventory and the fire control system already has a SUBDES[7] for firing it. *(Editor's Note: The Telfare device mounted a .50 caliber M2 MG on the M60 tank's gun barrel so it could be used in gunnery practice in lieu of shooting more expensive main gun rounds. The flight ballistics of the .50 and the main gun round were close enough to be comparable.)* Additionally, the concept of using a .50 caliber for this reason has long been effectively utilized in the tactical doctrine of the IDF. When the Telfare device was developed in the '70s, the IDF took the idea and refined the mount so that the .50 caliber would be more stable and could be used as a precision direct fire weapon. They learned early on that the original Telfare device had problems in maintaining a stable mount due to flexibility in its design. Though this may have been acceptable in training situations, it is not accurate enough for operational applications when trying to kill targets. The IDF still uses this adaptation in both operational and training situations, on several different weapons platforms. (See photos above.)

With a few modifications to stabilize the mount, and the addition of a tray to carry ammunition cans, the existing Telfare device could be used in a similar manner by the Abrams tank, especially if SLAP-T (Saboted Light Armor Piercing with Tracer) ammunition was used instead of the API-T (Armor Piercing Incendiary with Tracer) usually used in the Telfare device. Higher velocity SLAP-T ammunition travels on a flatter trajectory, making it more accurate at longer ranges. This system would allow the Abrams to accurately engage snipers and other lightly armored targets using an M2 machine gun, set on single shot, as a precision direct fire weapon.

Grenade Launchers

There are three ways that grenade launchers could be employed to improve the Abrams' capabilities in MOUT: by replacing one of the turret machine guns with a Mk 19 grenade launcher, by adding additional grenade launchers that fire HE grenades, or by adding a grenade launcher that could be aimed.

Simply switching the loader's machine gun with a Mk 19 grenade launcher is an immediate solution, enabling the Abrams to engage targets with



The French Galix grenade launching system. — Giat Photo

grenades in a 180-degree arc while maintaining the tank commander's ability to engage targets with a .50-caliber machine gun. However, the limitation of this solution is the fact that the loader could only fire the weapon while exposing himself to small arms and sniper fire — a significant threat in MOUT. So, while the Mk 19 might offer a valuable asset, it is not the total solution.

Additional grenade launchers could be added along the bustle rack and sponson boxes using a system like the Galix combat vehicle protection system, produced by Etienne Lacroix and Giat Industries of France.[8] The Galix protection system is currently mounted on the French Leclerc and Swedish Leopard 2A6 tanks. The system is comprised of three components, the firing unit, launcher, and ammunition. The firing unit is located inside the vehicle and the tank commander can select the number of grenades to be fired either singularly or in salvo. The launchers have a bayonet-type locking device that makes them insensitive to water and humidity by maintaining a seal, and holds the grenade securely in the tube. Launch tubes can accommodate an extended range of ammunition so that defense can be adapted to operational requirements. Grenades are fired on a flat trajectory to provide an almost immediate target effect. Grenades available for the Galix system are categorized as protective, flare, tear gas, decoy, stun effect, and smoke.

There are two grenade/mortar systems available that could be aimed. The first, produced by Krauss-Maffei Wegmann of Germany, is a 76mm adjustable grenade launcher system.[9] It could be incorporated into a redesigned loader's hatch that, if needed for a deployment, could be quickly changed. This launcher can be rotated 360 degrees, has a single launcher barrel that is breech loaded, and is normally set at a 45-degree angle but is capable of other angles. The device is loaded from within the vehicle using a small hatch and has a safety interlock that prevents firing if the hatch is not properly closed. An indicator on the mounting turntable indicates the direction of fire and grenades are fired electrically from inside the vehicle. Grenade types made for the launcher include smoke, tear gas, and HE. Having this device would enable the Abrams to lob grenades in the area surrounding the tank with the hatches closed.

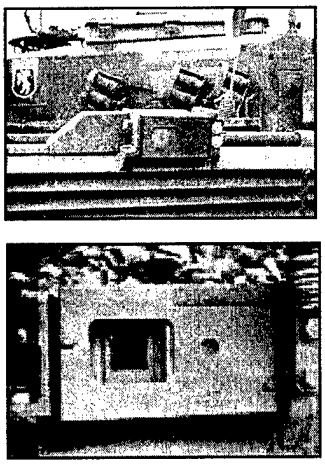
The second device is a 60mm breech loaded mortar, made by Soltam Defense Limited of Israel,[10] which can be aimed and fired by the loader from a closed hatch and is currently used on the Israeli Merkava tank. The loader inserts the mortar into a ball type firing port and aims and adjusts fire with the loader's periscope. To incorporate this device on the Abrams, one could again modify a loader's hatch by installing the ball type firing port, thus allowing the tank to engage the immediate area with 60mm mortar rounds.

Each of these grenade/mortar devices would require the modification of a predetermined number of loader's hatches that could be stockpiled for quick change onto vehicles deploying. Modifying only the loader's hatch would limit the money required for the modification to the predetermined number selected as the cache size.

Fiber Optic Cameras and Dead Space Security

The tanker's best friend in a MOUT environment is infantry running alongside and hiding behind the tank. Joined as a combined arms team, this complementary situation provides immediate security in the tank's dead space. In MOUT, more than any other environment, the tank crew is vulnerable to sniper fire and grenades being tossed into open hatches and will normally always be buttoned up. This makes the tank vulnerable to additional threats like the "sticky bombs" seen in the movie *Saving Private Ryan,* and other types of explosive devices delivered by an unseen dismounted soldier. To counter this threat, a MOUT-modified Abrams should have the capability of independently monitoring this critical area, so that if supporting infantry are unavailable, the tank can still maintain security in the tank's visibility dead space.

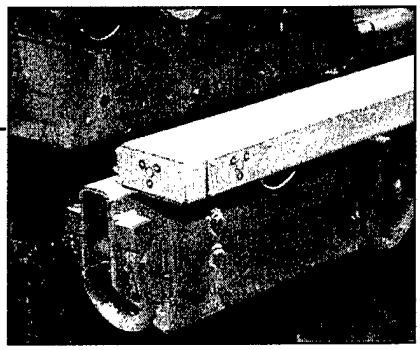
One solution is a variation of the Krauss-Maffei Wegmann driver's backward driving system. This system is currently being fitted onto Leopard 2A5 and 2A6 tanks and enables the driver to drive the tank backwards without assistance from the other crewmembers. It's a modular system consisting of a black and white monitor screen, video control unit, controlling elements and power supply mounted in the driver's compartment. The camera is housed in an armored box welded to the rear of the back deck, comprised of a black and white CCD camera with high sensitivity and resolution, and includes an automatic cleaning device. The door of the camera box opens automatically as soon as the driver places the tank in Reverse, with the driver's controls configured so that he does not move them any differently than when driving forward. The camera has a 54° x 72° viewing angle, allowing the driver to drive as fast backwards as he does forward. For purposes of MOUT, the system should be modified to allow the driver to independently open the door to overwatch this area of dead space.

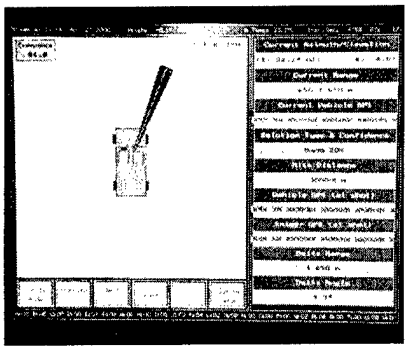


The Krauss-Maffei Wegmann rear-looking TV system allows the tank driver to move in reverse without assistance. The tiny camera, mounted in an armored box on the edge of the rear deck (see top photo), transmits a black-and-white image to a monitor in the driver's compartment.

- Photos: Jan deBoer

If this system were expanded and modified to mount cameras on the four





AAI Corporation's Projectile Detection and Cueing system tells the crew where incoming fire is coming from. The sensors, seen above left on the bumper of a HMMWV, feed information to the monitoring screen, at right. In this case, fire is coming from the right front.

- AAI Photos

cardinal aspects of the turret, the TC could view the area normally dead space when buttoned up, regardless of the positioning of the turret. The system should be set up to independently control the camera doors and view one or all cameras at once. Along similar lines, a parallel system of microphones and speakers could be installed to both hear and talk to personnel in the vicinity of the tank, bringing to fruition a situation like the car alarm that tells someone to "Step away from the vehicle."

Another area of observation that is sometimes overlooked, but critical in MOUT, is looking straight up. Tanks may find themselves next to buildings or other structures that require viewing the area directly above the tank. This can be accomplished by mounting a fiber optic camera — preferably thermal with a controllable pan/tilt mechanism — onto the bustle rack so that the TC can view this area.

One system that would also be invaluable in providing security in the tank's dead space and against snipers is a variation of the Projectile Detection & Cueing (PDCue™) Counter Sniper System available from the AAI Corporation of Maryland. (See photos above.) The PDCue system as designed will provide rapid real time data to locate and classify multiple firing situations directed at the tank. Detecting the sonic disturbance created by super sonic projectiles, it provides a compound defense and zonal monitoring in multiple configurations. PDCue displays this information on a screen that provides a visual display of attack direction in relation to the tank. Designed to provide real time output of azimuth, elevation, range, the caliber, miss distance, and GPS coordinates of the origin of fire, it gives a tank crew the ability to locate enemy snipers firing in the area of the tank. The system could also be integrated with a turreted weapon system to automatically traverse onto a sniper's location and remain stabilized to that location, making adjustments for vehicle movement. It could also be modified to incorporate other sensors that would allow monitoring of the tank's dead space with the addition of sonic or motion type sensors.

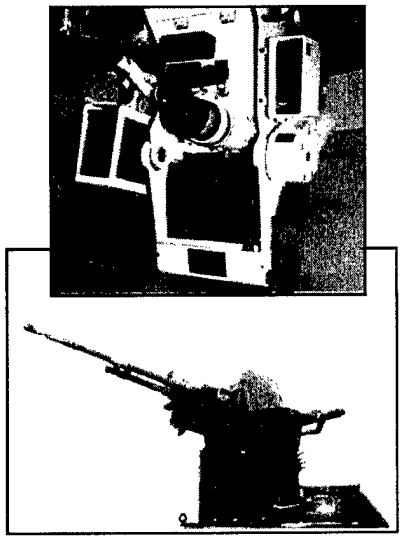
Cameras, microphones, and a speaker system in conjunction with an automatic monitoring system like PDCue would enable a tank crew to effectively monitor the dead space around the tank. Once detection of a threat in this area is achieved, then weapons can be brought to bear to destroy the threat or the tank can simply move away from the threat.

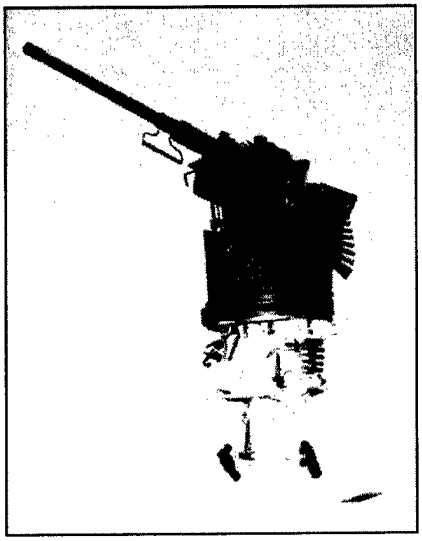
Overhead Weapons Systems (OWS)

An OWS is one way to enhance lethality and provide a way to accurately load and fire a machine gun while the tank is buttoned up. By assuming that the deploying tank is an M1A1, an OWS is easy to incorporate. Companies like Rafa'el from Israel, Krauss-Maffei Wegmann from Germany, and Otobreda from Italy have all developed OWSs for integration into a variety of armored vehicles. An OWS of the correct size could be mounted in the CITV ring, which is found on all M1A1s but covered by an armored plate.

The Rafa'el Ordnance Systems Division offers two OWSs that would fit this purpose, the OWS 12.7DI and OWS 7.62mm.[11] (See photos below.) Each features a day and night sight, weapon cocking from within the vehicle, internal (to the vehicle) ammunition feed, last round indication for internal reloading, closed hatch and head-out operating capability, electrically fired with mechanical backup, and an option on the 12.7DI that also allows for conversion to 7.62mm machine gun. Each system is a simple point and shoot device that enables loading and firing while the tank is buttoned up.

Krauss-Maffei Wegmann offers the Type 1865 remote-controlled gun mount





Israel's Rafa'el is one of several firms manufacturing overhead weapons systems that can be fired accurately from within a vehicle. At left is their 7.62 MG system, and at right is the .50 caliber version.

- Rafa'el Photos

system[12] that could be mounted on the side of the TC's cupola, similar to the way it mounts on a French AMX-30B2 tank. This powered gun mount can be fitted with a Type LZP 2050 sighting system that has a 1.5X to 7.5X power zoom sight, and ammunition for the weapon is fed from inside the vehicle. This system, though adaptable for the concept under discussion, may require modification of the M1A1's current cupola. However, like modifying loaders hatches to incorporate a grenade launcher, this would only require modification of a predetermined number of cupolas that could be inserted into the cupola rings of deploying tanks.

The Italian company, Otobreda, offers a power operated, remotely controlled, light turret[13] capable of mounting a caliber .50 machine gun. This two axis stabilized turret traverses via a joystick control system that is contained completely inside the vehicle. The control system protrudes into the turret and is independent from the movements of the gun in azimuth and elevation, remaining stationary. Sighting is performed by a special aiming telescope, which rotates with the turret and moves in elevation parallel to the gun. Weapon and turret movements are imparted by electric servomotors fed, together with the firing solenoid signals, through a slip ring — mounted coaxially with the aiming periscope. The weapon can be cocked from inside the vehicle and ammunition is fed through a flexible duct from boxes inside the vehicle. This system is also available with a low-light TV camera or thermal imager camera, with or without a laser range finder (LRF).

Each of these systems has merits and faults in its own right. The Rafa'el system would be simplest to install and easy to train a loader on its operation. The Krauss-Maffei Wegmann system may be cost prohibitive due to modifications required for the cupola, but deploying tanks could still be upgraded quickly with modified cupolas. The Otobreda system is the most technological system, with complexity akin to operating the turret. Regardless of complexity or cost, an OWS would provide an invaluable asset to a tank in a MOUT environment, bringing to bear a second weapon system, with the Otobreda and Rafa'el systems, able to engage targets above the maximum elevation of the tanks main armament, including the advantage of loading the weapon without exposing the crew.

Add-on Armor

Add-on armor will be needed to enhance the armor protection of an Abrams in MOUT from top attack. Packages can be added to the tank in one of two ways. One can either use modular passive type armor that molds and conforms to the vehicle's existing shape or a system of Explosive Reactive Armor (ERA) "bricks" can be mounted to the vehicle.

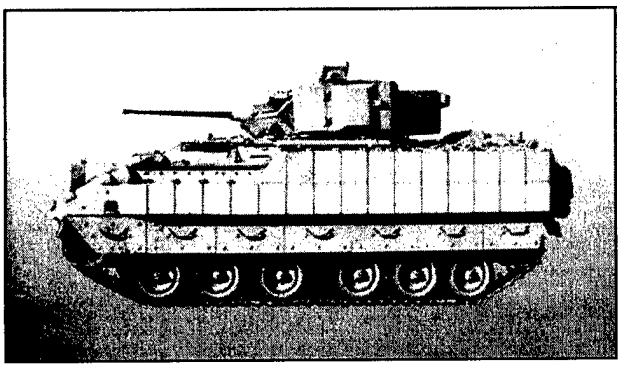
For years, the Russians have added ERA to upgrade the armor protection on main battle tanks. Israel has also fielded ERA and add-on armor packages for the last 20 years on a variety of vehicles to configure them for specific threat conditions. Israel has also been very tenacious in modifying, upgrading, and integrating captured armored vehicles through the use of ERA and add-on armor. American vehicles have used ERA to upgrade armor protection too, on the M60A1 for the Marines and some Bradley variants.

Either approach has its bad points, like the additional weight added to the vehicle, or the fact that ERA — once hit — becomes ineffective. Good points include the ability to upgrade a vehicle's protection without redesigning the base vehicle, and the ability to configure a vehicle's armor protection to a specific threat level.

In a hostile MOUT environment, the Abrams will likely face situations like what the Israelis encountered in southern Lebanon, where attack from above or from the side by RPGs and AT missiles posed a substantial threat. These situations led to modular add-on armor packages for the Merkava and also led to Israeli development of heavy APCs.

One ERA system currently available is from Giat Industries of France. They have developed the Brenus ERA block that can be easily fitted on all types of vehicles, giving them a high level of protection against HEAT projectiles.[14] The French Army has retrofitted its AMX-30B2 tank fleet with Brenus until those units can be fielded the Leclerc.

Rafa'el Ordnance Systems of Israel has three different types of add-on armor, including ERA.[15] Passive armor like the Enhanced Appliqué Armor Kit (EAAK) has been designed and fielded on M113s and other APCs and was selected by the Marine Corps for the AAV-7. This passive armor is based on a special spaced armor technology, highly efficient against KE projectiles and able to suppress the residual penetration of shaped charge munitions. Composite ceramic armor has also been developed and can be mounted as removable armor tiles. Reactive armor from Rafa'el began with the first generation of Blazer ERA in 1974, and was adopted for retrofitting the entire Israeli tank fleet at the time. First generation Blazer was also the ERA seen on Marine M60A1 upgrades in the late '80s, which was meant to upgrade the armor protection on the M60A1 until the Marines could field the Abrams tank. The latest generation, called Super Blazer, can be custom tailored as add-on armor for any type MBT, allowing for compatibility and operational requirements with all tank subsystems including optics, fire control systems, and guns. Super Blazer provides enhanced protec-



Rafa'el and Lockheed-Martin have developed a Super Blazer reactive armor package for the Bradley Fighting Vehicle.

- Rafa'el Photo

tion against shaped-charge munitions (like HEAT rounds and ATGMs) and increased efficiency against KE rounds. Rafa'el, together with Lockheed-Martin, also provides the latest reactive armor package for the Bradley Fighting Vehicle.

For the Abrams to be upgraded with add-on armor, a system using ERA blocks is not the answer. ERA blocks would involve the welding of mounting bolts to all the areas where the blocks are required. So the concept would not be uniformly applicable to the Abrams fleet. However, a modular — configurable — add-on armor package like that found on the Merkava could be custom fitted and tailored to specific threat levels. This modular package could be mounted with a slight modification to M1A1s as they are being deployed.

Canister Ammunition

A 120mm canister round has been designed to meet requirements set forth by U.S. Forces Korea for an anti-personnel round that is muzzle action and effective against massed troops 200-500 meters from the tank. Using tungsten steel balls or cubes, it could be used against a dismounted attack in numbers greater than could be effectively suppressed by the tank's machine guns. This round is not currently funded for production but would not take long to produce in numbers large enough to support forces that are deploying.

Conclusion

Having discussed the many available systems, here are the recommended features to improve the Abrams tank for MOUT operations.

- M2 .50 caliber mounted on an improved Telfare device firing SLAP-T.
- Switch out loader's M-240 for a Mk 19.
- Mount the Galix system, with a series of launchers attached to the rails along each sponson box and on the bustle rack rails.
- Modify a cache of loader's hatches to accommodate either the Krauss-Maffei Wegmann 76mm grenade launcher or Soltam 60mm mortar.
- Install a backward driving system.
- Install cameras, speakers, and microphones on the four cardinal aspects of the turret to enable the crew to see, hear, and talk to anyone close to the tank.
- Mount AAI's PDCue system.
- Mount either the Rafa'el 7.62mm or .50 caliber OWS in the CITV ring. (A rapidly deploying force will have little time to train a complex OWS.)
- Mount a modular add-on armor package to the turret roof and on the hull above the driver station.
- Add canister to the ammunition upload.

These features would enable Abrams tankers to adequately protect themselves while delivering precise, deadly, and accurate fires to the enemy, thus avoiding casualties in the civilian population.

The Russian tactical solution to MOUT is not a politically acceptable solution and is not one that Americans would embrace in situations short of all out war. Americans would also never accept the level of losses sustained by the Russians in the first Chechen war. A more tactful solution is through the deployment of technically superior fighting platforms like a MOUT-modified Abrams tank.

In open terrain, few dismounted soldiers or lightly armored vehicles will brazenly approach or attack a tank. Though tanks have a tendency to become "bullet magnets" on the battlefield, not many want to get into a slugfest with an Abrams.

War and battlefields are destructive and chaotic environments unlike any other human endeavor. American armor must face the reality of preparing to fight in MOUT. To think that American forces will not have to face combat in a MOUT environment with the Abrams tank is akin to the ostrich sticking its head in the sand. If adopted, this proposed concept would enable the Abrams tank to maintain a technological edge, even in the restricted confines of MOUT. "If we work on the prototype now, and put some ideas to work, we can make this a real option if it is needed."

The time is now for this concept to materialize and a future Armor Conference is the opportunity to exhibit these improvements to Armor leaders. An Abrams modified for MOUT would be the best answer to reinforcing an embattled rapid deployment force that needs the combat power of a tank in a MOUT environment.

Notes

[1]Yuri Babushkin, "Russia's Arms 2000," (*Military Parade,* 2000), p. 238.

[2]"Russia is using Chemical Weapons in Chechnya," (*Kavkaz-Tsentr,* 6 Dec 99), *http://www.fas.org/man/dod-101/ops/war/1999/12/991206-chechen-news.htm.*

[3]Timothy L. Thomas, "Grozny 2000: Urban Combat Lessons Learned," (*Military Review,* Jul-Aug 2000).

[4]CPT James D. Leaf, "MOUT and the 1982 Lebanon Campaign: The Israeli Approach," (*ARMOR,* Jul-Aug 2000), pp. 8-11.

[5]*FM 71-1,* Appendix I – MOUT.

[6]M179 Subcaliber Training Device Telfare, (*FM 17-12-7, Tank Combat Training Devices,* 11 Mar 92) p. 4-1.

[7]The ammunition sub-designation is used to tell the tank's fire control system the particular ballistic coefficient for the ammunition being fired.

[8]Tony Cullen and Christopher F. Foss, (*Jane's Armour and Artillery Upgrades,* Twelfth Edition, 1999-2000), pp. 149-150, hereafter referenced as *Jane's.*

[9]*Jane's,* p. 152.

[10] Soltam Systems Ltd., *http://www.army-technology.com/contractors/artillery/soltam/.*

[11]*http://www.Rafael.co.il.*

[12]*Jane's,* p. 289.

[13]*Jane's,* p. 300.

[14]Giat Industries website, *http://www.giat-industries.fr/ukgiat/prod/proa5a.htm.*

[15]Rafa'el Ordinance Systems website, *http://www.rafael.co.il.*

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F. The foregoing information was compiled and provided by:
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